ULTRASONIC TRANSCEIVER AND REMOTE CONTROLLED DEVICES FOR PETS

FIELD OF THE INVENTION

The field of the invention pertains to an ultrasonic transceiver to control output devices for use by and for pets and more particularly to a transceiver with modulation characteristics to improve range and avoid false triggering in the control of a wireless pet containment system; a sonic alarm for area restriction; a remote pet trainer and a remotely operated, fully automatic pet door.

BACKGROUND OF THE INVENTION

This invention has the purpose of facilitating a means by which pets can self activate automatic devices and allow humans to operate the devices remotely. The scope of this invention includes a modulated ultrasonic transceiver utilizing a fixed duration edge detect means to extend the range of the device by distinguishing between a low level transmitted signal and environmental noise. This is employed to control a wireless pet containment system; a sonic alarm for area restriction; a remote pet trainer and a remotely operated, fully automatic pet door but, its uses can easily be extended to other output devices.

PRIOR ART

Conventional devices utilizing ultrasound for remote sensing, such as ultrasonic burglar alarms, have been severely limited by the directionality, acoustical shadowing and limited range inherently characteristic of ultrasonic devices. For that reason they have been largely replaced by radio frequency and infrared transceivers.

In the pet field, electronic containment systems and remote trainers use radio frequency based transmitters and receivers. These devices are expensive to produce and severely restricted by the fact that they create interference to other radio frequency transmissions. To avoid this problem, manufactures must use extremely low power devices, practical for only very short range operation, or subject the design to restrictions placed upon it by regulating agencies such as the Federal Communications Commission. The use of ultrasound has been largely ignored as an alternative for the reasons listed above.

Electronic pet containment systems typically employ a radio frequency transmitter and an antenna in the form of a buried cable to enclose the perimeter of the containment area. As the pet wearing an R.F. receiver approaches the buried cable, a warning tone is sounded. Then, if the animal has not retreated from the perimeter after a predetermined time, an electric shock is delivered. Such systems present certain difficulties such as having to burry the cable.

Remote trainers typically use a hand held radio frequency transmitter to activate a single output (usually an electric shock or an irritating sound pulse) at the receiver worn by the pet. The single output of conventional systems is always used as a negative reinforcing stimulus rather than a positive enforcement of a specific behavior.

Conventional systems using sound to chase intruding animals from a restricted area use either infrared detection to sense the presence of the intruder (in much the same manner as a burglar alarm) or radio frequency. In addition to the fact that both such systems are relatively expensive to manufacture, the infrared system has the disadvantage that it will trigger on any warm body including humans and is

therefore not selective. A system of this type may work well in keeping the family dog off the couch but, it would also drive the people of the household away form the couch as well. The radio frequency systems are selective but, to date are limited to a range of less than four feet to avoid expense and unwanted R.F. interference.

It would therefore be desirable to create a remote transceiver system for pets to facilitate containment, training and area restriction which has relatively long range capability, which does not interfere with radio frequency devices nor is subject to the governmental restrictions of radio frequency devices, which is selective to an individual transmitted signal and which is relatively inexpensive to mass produce. The invention described herein provides such a system.

The current state of the art with respect to electronic pet doors is limited to devices which are operated by a magnet or a very low power R.F. transmitter worn on a pet's collar. The limited range of these transmitters restricts the design to smaller units suitable only for cats or small dogs. The transmitterused in this type of device merely acts to unlock a hinged panel to be physically pushed open by the pet and returned by gravity or a spring mechanism. The pet door device presented here uses the transmitted ultrasound to trigger the activation of an electric motor and transport mechanism to move a panel in and out of the door opening in a somewhat similar fashion to that of a power car window thereby, facilitating added security from intruders and weather and automatic operation requiring no human effort.

SUMMARY OF THE INVENTION

This invention makes practical use of the directionality inherent in ultrasonic transmission and offers a novel means of modulating the transmitted signal to increase the working range from a conventional twenty-five feet to over three hundred feet. This is achieved by delivering the ultrasonic signal output in periodic bursts. The receiver is designed to detect these bursts by sensing a repeated low to high transition at the amplifier input at predetermined intervals corresponding to the periodic rate of generation of ultrasonic bursts at the transmitter. Thus, sporadic environmental noise in the frequency range of the transceiver is essentially filtered out allowing the amplifier in the receiver to trigger on extremely low level signals.

Applied to the development of a wireless pet containment system, the present invention requires no antenna nor buried cable and specifically optimizes and makes use of the inherent directionality of ultrasound to approximate a linear beam of ultrasound forming a wireless boundary. The signal modulation and edge detect receiver virtually eliminate the possibility of false triggering which would allow the device to needlessly shock the animal. Additionally, it is possible to simultaneously send two individually modulated ultrasonic signals, one of higher amplification for a wider transmitted beam and one of lower amplification for a narrower transmitted beam, to separately control the warning tone and shock outputs at the receiver, making it impossible for a clever animal to run through the perimeter and out of range during the time delay from warning tone to shock used by conventional devices.

The invention in its present form also provides a useful alternative to the use of R.F. transmission in the creation of a remote training device by greatly extending the range of conventional ultrasonic transceivers. The result is a remote training device with a useful range comparable to that of a conventional R.F. transceiver but, without the possibility of interfering with the reception of radio, television and other

R.F. signals. The training device then uses one or more preset ultrasonic pulse rates to trigger one or more tones for use in obedience training of pets.

The directional characteristics of ultrasound are of great value applied to the operation of an automatic pet door by allowing an acceptable frontal activation range when the pet is facing and approaching receiver but, greatly reducing the probability of false triggering of the receiver when the pet is just passing by at even closer range than the frontal activation distance. The modulated pulsed signal and edge detect receiver technique are employed to create an ultrasonic key code so that the device may be operated only by the pet wearing a transmitter with those specific modulation characteristics to be sensed by the receiver. This type of pet door achieves the advantages of preventing stray animals and intruders from entering the home through the pet door (a common problem with conventional mechanical pet doors) and provides protection against strong wind which can easily blow through the hinged flap of a conventional pet door.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates the ultrasonic pet containment system.

FIG. 2 schematically illustrates the sonic alarm used for area restriction.

FIG. 3 schematically illustrates the remote pet trainer.

FIG. 4 schematically illustrates the automatic pet door.

FIG. 5 is a cross-section of the automatic pet door taken along lines 1—1

FIG. 6 is a vertical cross section of the automatic pet door taken along lines 2—2.

FIG. 7(*a*) is a block diagram of the ultrasonic transmitter.

FIG. 7(*b*) is a block diagram of the ultrasonic receiver.

FIG. 8 schematically illustrates an alternative embodiment of the pet containment system.

FIG. 9(*a*) illustrates the burst modulated ultrasonic wave form typically emitted by the ultrasonic transmitter showing the high to low transitions sensed by the receiver in the absence of environmental background noise.

FIG. 9(*b*) illustrates the burst modulated ultrasonic wave form typically emitted by the ultrasonic transmitter showing the high to low transitions sensed by the receiver in the presence of background noise of the same carrier frequency as the transmitter with typical sporadic peaks which are of greater amplitude than the transmitted ultrasonic signal.

FIG. 10 is a circuit diagram of the operational amplifier employed as part of the ultrasonic receiver.

FIG. 11 is an alternate embodiment of the pet containment system using two separate signals to individually control warning tone and shock outputs.

FIG. 12 is a cross-section of the receiver assembly.

FIG. 13 is an alternate embodiment of the receiver assembly.

FIG. 14 is a cross-section of the transmitter casings and positioning post used in the pet containment system.

FIG. 15 is a circuit diagram of the ultrasonic transmitter with modulator.

FIG. 16A is a diagram of the automatic pet door control circuit power supply.

FIG. 16B is a diagram of the automatic pet door control circuit motor controller.

FIG. 16C B is a diagram of the automatic pet door control circuit operational amplifier.

DETAILED DESCRIPTION

The present invention is an ultrasonic transceiver designed specifically to control various output devices for use by domestic animals. The output devices, which are also the subject of this invention, include a wireless pet containment system; a sonic alarm for area restriction; a remote pet trainer and a remotely operated, fully automatic pet door. The basic ultrasonic transceiver, shown in block form in FIGS. 7(*a*) and (*b*), utilizes a conventional quartz crystal controlled oscillator 1 to generate the carrier frequency. Ultrasonic frequencies of 32.7 KHZ and 40 KHZ are convenient because microphones, piezo speakers and quartz crystals of these values are readily available. The oscillated signal is fed to a modulator 2. FIG. 15 is an electrical schematic of the oscillator and modulator which together employ a "hex schmitt trigger" and "quad dual input schmitt NAND" integrated circuit to create a pulsed output consisting of periodic bursts of high frequency ultrasound of the type shown in FIG. 9(*a*). Various other modulation techniques may be employed to develop individual coded signals each to activate a separate functional output. These may include frequency modulation, amplitude modulation, pulse rate modulation, the generation of a pulse code or other techniques. The means employed in the embodiment of FIG. 15 simply varies the time interval between output bursts. The output amplitude is equal to the maximum plus and minus voltage supplied to the device which is typically limited to the maximum voltage rating of the integrated circuits of three to six volts direct current. The pulsed signal may be fed to an operational amplifier 3 to increase the working voltage supplied to the output speaker 4. The preferred embodiment employs a narrow band piezo transducer for the speaker due to its high efficiency. The electric current demand of such a device may be easily optimized to less than fifty microamperes facilitating the use of a small light-weight power source 5, such as a lithium coin cell battery, which can easily be worn by a pet with an acceptable useful life at the 50 microampere current consumption of six months to one year.

The receiver utilizes a narrow band piezo electric microphone 6 fed to a multi-stage operational amplifier 7 of the variety shown in FIG. 10. The use of discrete components, instead of commercial grade integrated circuits in this embodiment, allows quiescent electric current consumption of the receiver to be also limited to under 50 microamperes providing acceptable battery life from a light-weight lithium source 11.

The demodulation technique employs an edge detector which senses the low to high transition of the initial burst received at the amplifier. FIG. 9(*a*) shows that in the absence of background noise, the transition is measured from the zero state to the peak amplitude of the initial burst. As shown in FIG. 9(*b*) background noise shifts the zero baseline at each edge to the background level. The low to high transition is then sensed as the difference between the background level and the peak amplitude of the pulse. Once the first edge is detected, a timer is started with its duration equal to the interval between bursts of the transmitted signal. While the timer is running, the sensor is disabled so changes in background are not mistaken for another edge. At the end of the timing period the sensor resumes within a narrow time window. If a second edge is sensed within this time window it is taken as receipt of the modulated signal the output device 9 is activated. The technique may be repeated for multiple edge detect cycles before the output is activated, for added insurance against the probability of detecting a tran-

sition in the background noise which happens to occur within the edge detect time window. This technique greatly increases the working range of the device since it requires only a very small transition in ultrasound amplitude to trigger the device. The magnitude of that transition may be much less than the background ultrasound level. The fact that environmental background noise is generally sporadic with large momentary peaks, represents a problem to conventional devices which trigger on fixed signal levels and are apt to confuse a large background peak with the actual transmitted signal. In this device, background noise may be much larger than the minimum edge amplitude and indeed higher, at its peak, than that of the transmitted signal itself without affecting the sensitivity or range of the device. Even in worst case conditions where some unusual source of background noise level is high and of long, steady duration, it may only serve to mask some of the transmitted signal ultimately reducing range yet, it is still impossible for the device to trigger falsely on the background noise.

FIG. **14** shows the working elements of the receiver enclosed within tubular upper casing **10**. Speaker **4** is mounted inside tubular ultrasound shaping element **12** which is projected through a hole in the casing. The purpose of ultrasound shaping element **12** is to narrow the projected ultrasound envelope to more closely resemble a beam of ultrasound. Mounted within the casing is printed circuit board **13** with protruding contact spring **19** and leaf contact **20** contacting, respectively, the negative and positive terminals of lithium coin cell battery **14**. Battery retainer **15** is threaded into the casing to hold the battery in place and seal off one end of the casing. Cover **18** is pressed into the opposite end of the casing to seal that end. Lower casing **23**, identical to casing **10** and housing identical elements, is fitted into counter-bore **40** in the upper casing and allowed to rotate relative to that casing for proper positioning until secured in a fixed position by set screw **17** passing through a threaded hole in the counter-bored wall and into groove **16** thus, locking upper and lower casings rigidly together. Post **20** is fitted into counter-bore **41** of the lower casing. Set screw **42** of the lower casing passes through a threaded hole in the casing's counter-bored wall and into groove **22** in the post locking lower casing and post rigidly together.

FIG. **12** shows the receiver assembly in which housing **28** encases microphones **54** and **55** spaced 180 degrees apart to provide a direct line of sight to posts to the left and right of the animal as it approaches the boundary. Holes **69** and **70** provide sound paths to microphones **54** and **55**. Acoustical speaker **52**, pressed into integrally molded retaining cylinder **66**, generates the warning tone emitted through hole **52**. Battery holder **51** secures and contacts lithium coin cells **56** and **57** with access to the batteries provided by battery cover **53** secured to housing **28** with screws **62** and **63**. Microphones **54** and **55**, battery holder **51** and speaker **52** are wired to printed circuit board **50** providing the sensing, amplifying and output circuitry. Threaded electrodes **58** and **59** are soldered directly to printed circuit board **50** and protrude through holes in housing **28** and holes in strap **29** and secured to the housing with nuts **58** and **59**. This also secures strap **29** relative to housing **28** as it passes through integrally molded bezel slots **67** and **68**.

FIG. **1** schematically illustrates the interlaced ultrasound envelopes **26** created to form a perimeter when the receiver post **20** and like posts are placed in the ground with upper and lower receiver casings, **10** and **23** respectively, positioned to form the corners of the perimeter. The actual boundary line **27** is defined be the intersection of the inside leading edges of the ultrasound envelopes. Receiver casing **28** is attached to a domestic animal by strap **29** with buckle **30** looping through the receiver casing and around the animal's neck.

FIG. **8** schematically illustrates an alternate embodiment of the pet containment system whereby, a single transmitter inside casing **23** is mounted on post **20**. The transmitter casing is positioned so that the transmitted ultrasound envelopes a specific area off limits to the pet. Receiver casing **28** and mounting arrangement to the animal is identical to that shown in FIG. **1**.

FIG. **11** schematically illustrates the use of dual signal levels and modulations to define two separate boundary perimeters. Outside boundary area **31** is the area covered by the stronger signal. The modulation of this signal causes the receiver to generate a warning tone. That tone is delivered to the animal wearing the receiver when it crosses within outer perimeter **32**. Inside boundary area **33** is the area covered by the weaker signal. The modulation of this signal causes the receiver to generate an electric shock. The shock is delivered to the animal wearing the receiver when it crosses within inter perimeter **34**. This dual boundary technique is more effective in training the animal than the time delay method because the shock boundary is more clearly defined for the animal. Efforts on the part of the animal to run through the boundary before the shock is delivered are fruitless and the resultant containment system is more positive.

In the field of pet training, it has been shown by noted animal behaviorists that cats dogs and other animals respond positively to tones as training stimuli. The results of testing the training device described herein indicate that both dogs and cats can distinguish individual tones if separated by at least 1000 hertz. Each tone may then be used to positively enforce a specific behavior or command e.g. sit, stay, heal, come, fetch, etc. Negative stimuli, such as a loud piercing, tone or an electric shock may be used conjunctively to deter bad behavior and enforce the "NO!" command.

The training device of FIG. **3** utilizes the transceiver of FIGS. **7**(*a*) and (*b*) with outputs at the receiver capable of producing multiple tones with pitch separation of at least 1000 hertz, and an electric shock corresponding to preset modulated signals produced at the transmitter. The receiver is housed within casing **28** and strapped to the animal as in FIGS. **1** and **8**. The receiver assembly of FIG. **13** is similar that of FIG. **12** in all respects except that it utilizes a single microphone **65** oriented to face the ground when housing **28** is attached to the animal so that it may more easily sense the part of the transmitter signal which is reflected off the ground. This allows the device to be used effectively even when the animal is not facing the trainer so long as the line of sight between transmitter and animal is not obstructed.

The preferred embodiment of the sonic alarm system is shown in FIG. **2**. In this embodiment, transmitter and receiver positions used in the pet containment system are switched so that the receiver of FIG. **7**(*b*), which now activates a sonic alarm output device and visual flashing light each mounted within casing **73** with microphone **74**, alarm speaker **75** and flashing light element **78**, is stationary. The transmitter of FIG. **7**(*a*) is mounted within housing **72** and attached to a domestic animal by strap **76** with buckle **77** looping through the receiver casing and around the animal's neck. In this arrangement, transmitter housing **72** may be made quite small since there is no need for a tone generating speaker or shocking device providing a more comfortable and light weight device to be worn by the animal. Receiver casing **73** may now be easily positioned at any desired location such as couch, chair, kitchen table, etc.